

## **SELECTED WORKLOAD ELEMENTS OF THE MACHINE OPERATORS WORKING IN TIMBER HARVESTING. ERGONOMIC POINT OF VIEW**

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**Abstract.** Machine timber harvesting makes it possible to reduce substantially factors which have adverse impact on human health and which accompany manual-machine timber harvesting, presently predominating in Poland. The ergonomic factors classified into four following groups may be recognised as the main preconditions related to work with multi-operation machines: physical load – small energy expenditure, a very high value of repetitiveness and static efforts; mental load – high level of monotony, aesthenopia, a high level of stress; environmental load – significant limitation of hazard to operator's hearing, work under conditions of thermal comfort, reduced vibration hazard; organisational load – a relatively low risk of work – related accidents, making it possible to perform work operations throughout the year, continued employment, high work autonomy, independence in decision making, a possibility for workers to organise themselves and form work teams. The paper presents subjective perceptions and opinions of fifty operators of specialised machines with respect to their work load. Almost a half of the respondents worked over 50 hours per week. One third found their work conditions difficult. Work pace was recognised as particularly challenging to their well-being as merely 6% of respondents found it relatively low. Additionally, the selected elements of assessment of workstations under study in terms of energetic costs and noise load is discussed. The maximum energy expenditure of a machine operator is related to operations performed outside a cab: tuning up, routine maintenance, and repairs. Energy expenditure related to work inside a cab did not exceed 14 kJ/min. Noise level in a low-noise cabin was lower than sixty dB(A). Use of machines to a large degree eliminates important health-adverse factors accompanying combined machine-driven and manual timber harvesting, however, it creates conditions favouring occurrence of new ailments and diseases, totally different from those which have been recorded so far in forestry.

**Key words:** forestry, operators, work load, ergonomics

## INTRODUCTION

Machine timber harvesting leads to considerable elimination of health-adverse factors, which are related to combined machine and manual timber harvesting, which currently predominates in Poland. The ergonomic factors classified into the following groups may be recognised as the main preconditions related to work with multi-operation: machines physical load – small energy expenditure, a very high value of repetitiveness and static efforts; mental load – high level of monotony, aesthenopia, a high level of stress; environmental – independence of weather conditions, significant limitation of hazard to operator's hearing, work under conditions of thermal comfort, reduced hand arm vibrations (HAV) hazard; organisational – a relatively low risk of work-related accidents, making it possible to perform work operations throughout the year, continued employment, high work autonomy, independence in decision making, a possibility for workers to organize themselves and form work teams [Sowa 2007].

Use of machines creates conditions favouring occurrence of new ailments and diseases, totally different from combined manual-work driven work which have been so far used in forestry. The following factors are gaining in importance: repetitiveness and automation of works, movements and work operations, long-lasting and rather not diversified activity of certain groups of muscles, aesthenopia, exposure to whole body vibration (WBV), hazards related to cab microclimate, maladaptation of a multi-operation machine interface to individual capabilities of an operator, complexity of the performed tasks, related to special requirements of operator's cognitive and perceptive capabilities and operator's concentration, mental load resulting among others from multiplicity of decisions made within a given time window, shift work as factor disturbing operator's circadian rhythm, working alone, often far from family (work out of a place of residence). A machine owner who is also an operator would be subjected to particular loads. A contractor works under additional stress caused by special organisational (winning and maintaining contracts for work), financial and/or extensive responsibility for employees [Jodłowski 2000, Moskalik 2002].

## AIM OF THE STUDY

The multi-aspect study carried out on mechanical workstations in forestry aimed at the following:

- 1) learning the ergonomic preconditions for work at those workstations
- 2) defining attitudes, needs, expectations of specialised machine operators related to: work conditions and organisation, workstation, and an employing company.

## RANGE OF THE STUDY

The author has been conducting the multi-aspect research on operators of specialised machines used in forestry for over a decade, paying special attention to timber harvesting. The main elements covered with the research include the following:

1. Anthropometric preconditions – the basic machine operator’s dimensions in relation to working space inside a cabin and structure of work movements.
2. Preconditions associated with work physiology – physical capacity, energy expenditure during operators’ work.
3. Preconditions associated with exposure to ambient factors in operator’s work.
4. Organisational preconditions.
5. Accident hazard.

Operators in specialised machines used for timber harvesting, machines themselves and occupational conditions were covered with the studies.

This paper presents selected elements of the multi-aspect research.

### **Study subjects**

Fifty operators in total were studied, they represented the main employment types: employees working permanently for “State Forests” National Forest Holding units, self-employed workers using machines owned by forest divisions, equipment owners who work on their machines, employees of private companies. Eight workdays were studied (4 for operations with a harvester and 4 for operations with forwarders). Energy expenditure was measured with a WE-1 instrument (manufactured by the Central Institute for Labour Protection).

### **Occupational environment**

An analysis of the selected features of the occupational environment was performed for two harvesters (Timberjack 1270B, Valmet 911.1) and two forwarders (Ponsse Caribou, Timberjack 1110D). Temperature and relative humidity in a cab (using a LB-701 thermo-hygrometer), lighting in the working space (with a L-50 luxometer), and noise in a cab (integrating sound level meter SON-50) were measured. The analyses were carried out during work with machines under autumn-winter conditions with air conditioning switched on, at outside temperature of 5-9°C. Work performed in the morning and early afternoon was analysed.

## **MATERIAL AND METHODS**

The methods meeting the needs of the individual research fields were applied in this multidisciplinary study. The methodology used for physiological, anthropometric, and environmental studies is compliant with the methodology used in detailed sciences and was specified in earlier papers [Nowacka 1995, 2009, 2011].

A standardised questionnaire supplemented with face-to-face interviews recorded on magnetic media was the research tool used for collecting information on the operators, their attitudes, needs and expectations.

**The questionnaire** [Nowacka 2009] included closed questions, usually with multi-part alternatives (mainly a disjunctive cafeteria, allowing for a single choice, in a small part a conjunctive one, allowing for multiple answers), partly two-part (dichotomous) alternatives and semi-open questions. The closed questions included either a list or a five-point scale. Apart from explanation of the study aim, the questionnaire included

instructions on how to fill in responses to the questions. As regards the questionnaire topics, they fall in ten subject areas:

1. Personal background.
2. Work background.
3. Typical workday.
4. Current work.
5. Work organisation.
6. Technical ergonomics.
7. Sickness and fatigue.
8. Physical symptoms
9. Psychosocial factors I.
10. Psychosocial factors II.

## RESULTS AND DISCUSSION ELEMENTS

### Hygienic parameters of the occupational environment

Ergonomic preconditions of the physical working environment may be assessed basing on an analysis of selected cab microclimate features, noise level inside a cab and lighting intensity. The average ambient temperature equalled 23.1°C (range 19.5-24.3°C). Relative humidity equalled on average 29.5% (range 28.1-35.0%). Climatic parameters inside a cab are a factor which to a large degree determines operator's comfortability during work. Maintaining temperature and humidity parameters at a stable level under diversified field conditions (variable insolation, long working hours, early time of work start) is not easy. The process is much less complicated in a large cab than in a small one. Conditions inside a cab depend not only on air-conditioning performance but also on internal cab design, applied materials, an insulation level, etc. Operator cabs should meet the essential ergonomic requirements, specified among others in the ergonomic checklist for forest machines [Almqvist et al. 2006].

In cabs under analysis the equivalent noise level did not exceed 70 dB (A). That value indicates that the work conditions under study meet the essential ergonomic requirements. The results are confirmed by the studies by Giefing et al. [2005], and Leszczyński [2011]. During complex tasks performed by an operator, the recorded average noise level of 66 dB(a) may present some difficulty under conditions of long-lasting work without intervals. However, that is not hazardous to human health.

In cabs under study lighting of various work planes was compliant with the requirements for visual work. Shadowiness was small, in line with the requirements of the applicable standards.

Taking into account the ergonomic requirements, the cabins under study were found to meet the basic requirements in terms of temperature, noise and lighting of the work place surface. Bearing in mind the nature of operator's work (considerable mental load, to a large degree work similar to work at a computer station), one could say that the value of relative humidity below 40% RH constitutes a major hindrance to the work which requires precision, self-control, intellectual commitment, effective thinking and decision making [Nowacka 2009]. Also the noise level over 50 dB (A) may affect effectiveness of long operator's work.

## Energy expenditure (WE) during a workday

Table 1. Energy expenditure for the selected work activities of a harvester/forwarder operator (average values)

Tabela 1. Koszt energetyczny dla wybranych czynności roboczych operatora harwestera, forwardera (dane uśrednione)

Activity Czynność	Average unit WE WE jednostkowy uśredniony KJ/min
Head manoeuvring Manewrowanie głowicą	13.50
Crane manoeuvring Manewrowanie chwytkiem	13.40
Drives between trees Podjazdy pomiędzy drzewami	12.56
Unloaded forwarder driving Przejazdy forwarderem bez ładunku	12.10
Set-up time Czas przygotowawczo-zakończeniowy	12.56
Workstation servicing, refuelling, tuning-up Obsługa stanowiska roboczego, tankowanie, regulacja	15.10
Auxiliary time Czas pomocniczy	13.5
Breaks Przerwy	7.95

In terms of energy expenditure, work of a specialised machine operator may be classified as light or very light.

## Selected results of questionnaire survey

When evaluating their typical workdays, operators assessed twelve aspects of the performed professional tasks. In the opinions of their work, they stressed the following issues:

- an insufficient number of work breaks, at the same time indicating the fact that a break may be decided and enjoyed by employees themselves; due to time pressure and economic preconditions, operators rarely make use of breaks
- difficult working conditions which were indicated by 42% of respondents; that factor was more often stressed by employees aged 36-45 years
- physical fatigue (stressed by 48% of respondents, in particular those over 45) and mental fatigue after work (34%)
- low position variability which affects operator's health (82% of respondents)
- low potential for planning and arranging their own work (that issue is mentioned by every second operator); a lack of those possibilities affects particularly older employees (over 45)

- no possibility to decide about their work by the operators covered with the study did not affect evaluation of their work in terms of stimulation for an employee; to most of the respondents (60%), operator's job was interesting and stimulating
- every fifth employer found a workday as adequately active in terms of social life; others complained about loneliness at work.

Older workers (over 45 years) were more often critical about their work, their perceive it more intensely than younger age groups. The operators covered with the study found their work as not guaranteeing total safety in terms of permanency of employment, activity, and business operations. 38% of respondents gave such an answer to the question: what problems do you encounter during your work, professional activity? Further issues that respondents stressed included the following:

- insufficient salary, which is inadequate to work effort and means involved (36%)
- no prospect for development in terms of a professional career (22%)
- problems with work organisation, excessive physical load, too long working hours (18% each of the elements)
- excessive mental load, inappropriate working conditions and occupational safety (12% each).

As other factors adversely disturbing their work, operators most often mention the following:

1. No appropriate collaboration with units of the "State Forests" National Forest Holding which administers forests.
2. No appropriate collaboration with chainsaw operators who prepare a workplace when trees are cut with a saw and timber is skidded with a forwarder.
3. Problems with repairing machines which frequently break down, no appropriate and easily available service.
4. No logistics used for planning work spaces, task succession, order of operations and access for various companies. No effective coordination of tasks performed within the same working space.

The operators under study often said (the opinion of 43% of respondents) that they were not trained on work techniques. The operators agreed (over 50% of positive answers of private and state-owned company employees), that both their immediate superiors and the supervising staff were trained so that they very well understood the effects of work and its management on the operators' health.

## SUMMARY AND CONCLUSIONS

Basing on the obtained results one could say that the operators under study crave for knowledge and training. They are aware of importance of ergonomic factors to their health and long-term professional capability, they expect the ergonomic criteria to be satisfied and healthy and productive working conditions provided. They are aware (and they articulate it) that successful implementation of mechanization under Polish conditions, will depend to a large degree on involvement of employees themselves, operators and contractors into decision making processes. I mean here decisions pertaining both to a choice of machines, work planning and performing individual tasks and a system of modern training for newcomers and already employed operators.

Complete and rational utilisation of the available staff operators requires appropriate additional training. Basing on the expectations of would-be training addressees will contribute to higher effectiveness of actions taken in that field. The concept of a worker being a partner responsible for his or her actions, having broad decision making qualifications has appeared only in recent years and will not disappear from the labour market. That is evidenced by the clear global trends. Therefore, in the course of occupational training our operators have to receive appropriate knowledge and learn skills that will make it possible for them to work in a comprehensive and responsible, competent and effective (in terms of decision making) manner. Entrepreneurship in a good sense should become an element of knowledge gained at all the educational levels.

Basing on the acquired knowledge and the collected data on machine operators the author believes that the needs related to human resources will be growing in the next two decades. That constitutes a challenge to education and science, that are to provide adequate support for the growing sector of forest services, which could fill-in the educational and training gap in operators' education.

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## WYBRANE ELEMENTY OBCIĄŻENIA PRACĄ OPERATORA SPECJALISTYCZNYCH MASZYN STOSOWANYCH W POZYSKIWIANIU DREWNA. ERGONOMICZNY PUNKT WIDZENIA

**Streszczenie.** Maszynowe pozyskiwanie drewna sprawia, że w dużym stopniu likwidacji podlegają negatywne dla zdrowia człowieka czynniki występujące przy ręczno-maszynowym pozyskiwaniu drewna dominującym aktualnie w Polsce. Jako zasadnicze uwarunkowania pracy maszynami wielooperacyjnymi można wyróżnić ergonomiczne czynniki ujmowane w czterech grupach: obciążenie fizyczne – niewielki wydatek energii, bardzo duża wartość monotonii i wysiłku statycznego; obciążenie psychiczne – wysoki poziom monotonii, przeciążenie narządu wzroku, duży stres; środowiskowe – istotne ograniczenie zagrożeń dla słuchu operatora, praca w komforcie termicznym, zmniejszone zagrożenie związane z wibracją; organizacyjne – relatywnie małe ryzyko wypadków przy pracy, umożliwienie realizacji operacji roboczych w ciągu całego roku, ciągłość pracy, duża autonomia pracy, samodzielność w podejmowaniu decyzji, możliwość organizowania się i dobierania w grupy robocze. W pracy przedstawiono subiektywne odczucia i opinie pięćdziesięciu operatorów specjalistycznych maszyn na temat ich obciążenia pracą. Bliższe połowa badanych poświęcała na pracę w tygodniu powyżej 50 godzin. Jedna trzecia badanych określa warunki pracy jako trudne. Jako szczególnie dokuczliwe dla dobrostanu operatora odbierane jest tempo pracy, które jedynie przez 6% badanych jest odbierane jako względnie małe. Jednocześnie w pracy omówiono wybrane elementy oceny ergonomicznej badanych stanowisk pracy z punktu widzenia kosztu energetycznego, obciążenia słuchu hałasem. Maksymalny wydatek energii operatora maszyny dotyczy prac wykonywanych poza kabiną: regulacja, obsługa codzienna, naprawy. Praca w kabinie wiąże się z wydatkiem energii nieprzekraczającym 14 kJ/min. Poziom hałasu w prawidłowo wyciszonej kabinie maszyny nie przewyższa wartości sześćdziesięciu dB (A). Stosowanie maszyn likwiduje w dużym stopniu istotne, negatywne dla zdrowia człowieka czynniki występujące przy ręczno-maszynowym pozyskiwaniu drewna, kreuje jednak równocześnie warunki sprzyjające powstawaniu nowych dolegliwości i chorób całkowicie odmiennych od dotychczas występujących w leśnictwie.

**Słowa kluczowe:** leśnictwo, operatorzy, obciążenie pracą, ergonomia

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